[6450-01-P]

DEPARTMENT OF ENERGY

[DOE/EIS-0542]

Record of Decision for the Final Versatile Test Reactor Environmental Impact Statement

AGENCY: Idaho Operations Office, Department of Energy.

ACTION: Record of decision.

SUMMARY: The Department of Energy (DOE) is issuing this record of decision (ROD) for the Versatile Test Reactor (VTR) pursuant to the *Final Versatile Test Reactor Environmental Impact Statement* (VTR EIS) (DOE/EIS-0542). DOE prepared the VTR EIS to evaluate the potential environmental impacts of alternatives for constructing and operating a VTR and the associated facilities required for post-irradiation examination of test and experimental fuels and materials. DOE has decided to implement its Preferred Alternative, to construct and operate a VTR at the Idaho National Laboratory (INL) Site, and to establish, through modification and construction, co-located facilities for post-irradiation examination of test products and for management of spent VTR driver fuel at INL. The VTR will operate as a national user facility, providing a fast-neutron-spectrum test capability for the testing and development of advanced nuclear technologies. DOE has not decided whether to establish VTR driver fuel production capabilities at the INL Site, the Savannah River Site (SRS), or a combination of the two sites. Once a preferred alternative or option for VTR driver fuel production is identified, DOE will announce its preference in a *Federal Register* (FR) notice. DOE would then publish a ROD no sooner than 30 days after its announcement of a preferred alternative/option for VTR driver fuel production.

ADDRESSES: Questions or comments should be sent to Mr. James Lovejoy, VTR EIS Document Manager, by mail at U.S. Department of Energy, Idaho Operations Office, 1955 Fremont Avenue, MS 1235, Idaho Falls, Idaho 83415; or by e-mail to

VTR.EIS@nuclear.energy.gov. The Final VTR EIS and this ROD are available for viewing or download at *https://www.energy.gov/nepa/nepa-documents* and *https://www.energy.gov/ne/nuclear-reactor-technologies/versatile-test-reactor*.

FOR FURTHER INFORMATION CONTACT: For information regarding the VTR Project, the Final VTR EIS, or the ROD, visit *https://www.energy.gov/ne/nuclear-reactor-technologies/versatile-test-reactor*; or contact Mr. James Lovejoy at the mailing address listed in **ADDRESSES** or via email at *VTR.EIS@nuclear.energy.gov*; or call (208) 526-6805. For general information on DOE's National Environmental Policy Act (NEPA) process, contact Mr. Jason Anderson at the mailing address listed in **ADDRESSES** or via email at *VTR.EIS@nuclear.energy.gov*; or call (208) 526-6805.

SUPPLEMENTARY INFORMATION:

Background

DOE's mission includes advancing the energy, environmental, and nuclear security of the United States (U.S.) and promoting scientific and technological innovation in support of that mission. DOE's 2014 to 2018 Strategic Plan states that DOE will "support a more economically competitive, environmentally responsible, secure and resilient U.S. energy infrastructure." The plan further indicates that DOE will continue to explore advanced concepts in nuclear energy. The advanced concepts may lead to new types of reactors that improve safety, lower environmental impacts, and reduce proliferation concerns.

Advanced reactors that operate in the fast-neutron[1] spectrum offer the potential to have inherent safety characteristics incorporated into their designs. They can operate for long periods without refueling and reduce the volume of newly generated nuclear waste. Effective testing and development of advanced reactor technologies requires the use of fast neutrons comparable to

[1] Fast neutrons are highly energetic neutrons (ranging from 0.1 million to 10 million electron volts [MeV] and travelling at speeds of thousands to tens of thousands kilometers per second) emitted during fission. The fast-neutron spectrum refers to the range of energies associated with fast neutrons.

those that would occur in actual advanced reactors. A high flux of fast neutrons allows accelerated testing, meaning that a comparatively short testing period would accomplish what would otherwise require many years to decades of exposure in a test environment with lower energy neutrons, a lower flux, or both. This accelerated testing would contribute to the development of materials and fuels for advanced reactors and generate data allowing advanced reactor developers, researchers, DOE, and regulatory agencies to improve performance, understand material properties, qualify improved materials and fuels, evaluate reliability, and ensure safety. Accelerated testing capabilities would also benefit these same areas for the current generation of light-water reactors.

Many commercial organizations and universities are pursuing advanced nuclear energy fuels, materials, and reactor designs that complement DOE and its laboratories' efforts to advance nuclear energy. These designs include thermal[2] and fast-spectrum reactors that target improved fuel resource utilization and waste management, and the use of materials other than water for cooling. Their development requires an adequate infrastructure for experimentation, testing, design evolution, and component qualification. Available irradiation test capabilities are aging (most are over 50 years old). These capabilities are focused on testing materials, fuels, and components in the thermal neutron spectrum and do not have the ability to support the needs for fast reactors (i.e., reactors that operate using fast neutrons). Only limited fast-neutron-spectrum testing capabilities, with restricted availability, exist outside the U.S.

A number of studies evaluating the needs and options for a fast-neutron spectrum test reactor have been conducted. The *Advanced Demonstration and Test Reactor Options Study* identified a strategic objective to "provide an irradiation test reactor to support development and qualification of fuels, materials, and other important components/items (*e.g.*, control rods,

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[2] Thermal neutrons are neutrons that are less energetic than fast neutrons (generally, less than 0.25 electron volt and travelling at speeds of less than 5 kilometers per second), having been slowed by collisions with other materials such as water. The thermal neutron spectrum refers to the range of energies associated with thermal neutrons.

instrumentation) of both thermal and fast neutron-based…advanced reactor systems." The DOE Nuclear Energy Advisory Committee (NEAC) issued an *Assessment of Missions and Requirements for a New U.S. Test Reactor*, confirming the need for fast-neutron testing capabilities in the U.S. and acknowledging that no such facility is readily available domestically or internationally. Developing the capability for large-scale testing, accelerated testing, and qualifying advanced nuclear fuels, materials, instrumentation, and sensors is essential for the U.S. to modernize its nuclear energy infrastructure and to develop transformational nuclear energy technologies that re-establish the U.S. as a world leader in nuclear technology commercialization.

DOE's *Mission Need Statement for the Versatile Test Reactor (VTR) Project, A Major Acquisition Project* embraces the development of a well-instrumented, sodium-cooled, fast-neutron-spectrum test reactor in the 300 megawatt-thermal power level range. The deployment of a sodium-cooled, fast-neutron-spectrum test reactor is consistent with the conclusions of the test reactor options study and the NEAC recommendation.

As required by the Nuclear Energy Innovation Capabilities Act of 2017 (NEICA) (Pub. L. 115–248), DOE assessed the mission need for a VTR-based fast-neutron source to serve as a national user facility. Having identified the need for the VTR, NEICA directs DOE "to the maximum extent practicable, complete construction of, and approve the start of operations for, the user facility by not later than December 31, 2025." The Energy Act of 2020, within the Consolidated Appropriations Act (Pub L. 116-68), directs the Secretary of Energy to provide a fast-neutron testing capability, authorizes the necessary funding, and revises the completion date from 2025 to 2026. To this end, DOE prepared an EIS in accordance with NEPA and the

Council on Environmental Quality (CEQ) and DOE NEPA regulations (40 CFR parts 1500 through 1508[3] and 10 CFR part 1021, respectively).

Purpose and Need for Agency Action

The purpose of this DOE action is to establish a domestic, versatile, reactor-based fast-neutron source and associated facilities that meet identified user needs (*e.g.*, providing a high neutron flux of at least 4×10^{15} neutrons per square centimeter per second and related testing capabilities). Associated facilities include those for the preparation of VTR driver fuel and test/experimental fuels and materials and those for the ensuing examination of the test/experimental fuels and materials; existing facilities would be used to the extent possible. The U.S. has not had a viable domestic fast-neutron-spectrum testing capability for almost three decades. DOE needs to develop this capability to establish the U.S. testing capability for next-generation nuclear reactors—many of which require a fast-neutron spectrum for operation—thus enabling the U.S. to regain technology leadership for the next generation nuclear fuels, materials, and reactors. The lack of a versatile fast-neutron-spectrum testing capability is a significant national strategic risk affecting the ability of DOE to fulfill its mission to advance the energy, environmental, and nuclear security interests of the U.S. and promote scientific and technological innovation. This testing capability is essential for the U.S. to modernize its nuclear energy industry. Further, DOE needs to develop this capability on an accelerated schedule to avoid further delay in the U.S. ability to develop and deploy advanced nuclear energy technologies. If this capability is not available to U.S. innovators as soon as possible, the ongoing shift of nuclear technology dominance to other nations will accelerate, to the detriment of the U.S. nuclear industrial sector.

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[3] On July 16, 2020, the CEQ published an "Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act" (85 FR 43304). CEQ clarified that these regulations apply to NEPA processes begun after the effective date of September 14, 2020, and gave agencies the discretion to apply them to ongoing NEPA processes (40 CFR 1506.13). This VTR EIS was started prior to the effective date of the revised CEQ regulations, and DOE has elected to complete the EIS pursuant to the regulations in effect prior to September 14, 2020 (1978 regulations).

Proposed Action

DOE proposes to construct and operate the VTR at a suitable DOE site. DOE would use or expand existing, co-located, post-irradiation examination capabilities as necessary to accomplish the mission. DOE would also use or expand existing facility capabilities to produce VTR driver fuel and to manage radioactive wastes and spent nuclear fuel. The DOE facilities would be capable of receiving test articles from the user community, as well as fabricating test articles for insertion in the VTR.[4]

Candidate sites for construction and operation of the VTR include the INL Site near Idaho Falls, Idaho, and the Oak Ridge National Laboratory (ORNL), near Oak Ridge, Tennessee. DOE would perform most post-irradiation examination in existing, modified, or new facilities near the VTR, although there may be instances when test items would be sent to another location for evaluation. DOE would produce VTR driver fuel at the INL Site or SRS near Aiken, South Carolina.

Alternatives and Options Analyzed in the Final VTR EIS

DOE proposes to use the GE Hitachi Nuclear Energy (GEH) Power Reactor Innovative Small Module (PRISM), a pool-type reactor, as the basis for VTR's design under both action alternatives. The PRISM design would require several changes, notably the elimination of electricity production and the accommodation for experimental locations within the core. The PRISM design[5] of a sodium-cooled, pool-type reactor satisfies the need to use a mature technology. The VTR would be an approximately 300-megawatt (thermal) reactor based on and

[4] As a user facility, the VTR would provide experimental capabilities for entities outside of DOE. These other entities could also fabricate test items for placement in the reactor. The VTR project would develop procedures for the acceptance of test items for use in the VTR. All test item and assembly designs would be reviewed and verified to ensure that the VTR would perform as designed and would meet all core performance and safety requirements before the test assembly could be inserted into the reactor core.
[5] The PRISM design is based on the EBR-II reactor, which operated for over 30 years. The PRISM design most like the VTR is the 471-megawatt thermal MOD-A design. The U.S. Nuclear Regulatory Commission review of the PRISM reactor, as documented in NUREG-1368, *Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid-Metal Reactor*, concluded that "no obvious impediments to licensing the PRISM design had been identified."

sharing many of the design and passive safety features of the GEH PRISM. It also would incorporate technologies adapted from previous sodium-cooled fast reactors (*e.g.,* the Experimental Breeder Reactor II [EBR-II] and the Fast Flux Test Facility). The VTR's reactor, primary heat removal system, and safety systems would be similar to those of the PRISM design. VTR, like PRISM, would use metallic alloy fuels. The conceptual design for the first VTR driver fuel core is an alloy of 70 percent uranium (uranium enriched to 5 percent uranium-235[6]), 20 percent plutonium, and 10 percent zirconium (by weight).

The major facilities in the VTR complex include an electrical switchyard, the reactor facility, 10 large sodium-to-air heat exchangers, and an operational support facility. The reactor facility would be about 180 feet by 280 feet. The reactor vessel, containing the core of the VTR, would extend 90 feet below grade. Other below-grade elements of the facility include the reactor head access area (over the core), secondary coolant equipment rooms, test assembly storage areas, and fuel cask pits. The reactor and experiment hall operating area that extends 90 feet above grade would allow the receipt and movement of fuel and experiments into and out of the core and storage areas.

The VTR core design would differ from that of PRISM because it needs to meet the requirement for a high-flux test environment that accommodates several test and experimental assemblies. Experiments would be placed in some locations normally occupied by driver fuel in the PRISM. Heat generated by the VTR during operation would be dissipated through a heat rejection system consisting of intermediate heat exchangers within the reactor vessel, a secondary sodium-cooling loop, and air-cooled heat exchangers. This system and the Reactor Vessel Auxiliary Cooling System (RVACS) would provide shutdown and emergency cooling. The RVACS would remove decay heat from the sodium pool by transferring the thermal energy

[6] Enriched refers to the concentration of the isotope uranium-235, usually expressed as a percentage, in a quantity of uranium. Low-enriched uranium (LEU), highly enriched uranium (HEU) and high assay, low-enriched uranium (HALEU) are all enriched forms of uranium. Depleted uranium is a byproduct of the enrichment process and refers to uranium in which the percentage of uranium-235 is less than occurs naturally.

through the reactor vessel and guard vessel walls to naturally circulating air being drawn down through the inlets of four cooling chimneys, through risers on the exterior of the guard vessel, and up through the outlets of the cooling chimneys. The RVACS chimneys would be about 100 feet tall, extending above the experiment support area. No water would be used in either of the reactor cooling systems.

The core of the VTR would comprise 66 driver fuel assemblies. The core would be surrounded by rows of reflector assemblies (114 total assemblies), which would be surrounded by rows of shield assemblies (114 total assemblies). Non-instrumented experiments (containing test specimens) could be placed in multiple locations in the reactor core or in the reflector region, by replacing a driver fuel or reflector assembly (test pins may also be placed within a driver fuel assembly). Instrumented experiments, which would provide real-time information while the reactor is operating, would require a penetration in the reactor cover for the instrumentation stalk and could only be placed in six fixed locations. One of these six locations can accommodate a "rabbit" test apparatus that would allow samples to be inserted and/or removed while the reactor is in operation. The number of instrumented test locations, plus the flexibility in the number and location of non-instrumented tests would strengthen the versatility of the reactor as a test facility.

The VTR mission requires capabilities to examine the test specimens after irradiation in the VTR to determine the effects of a high flux of fast neutrons. Highly radioactive test specimens would be removed from the VTR after a period of irradiation ranging from days to years. Test specimens would then be transferred to a fully enclosed, radiation-shielded facility where they could be remotely disassembled, analyzed, and evaluated. The examination facilities are "hot cell" facilities. These hot cells include concrete walls and multi-layered, leaded-glass windows several feet thick. Remote manipulators allow operators to perform a range of tasks on test specimens within the hot cell while protecting them from radiation exposure. An inert atmosphere is required in some hot cells. An inert atmosphere of argon would be used[7] in the hot cell to which test assemblies are initially transferred after removal from the VTR. The inert atmosphere may be necessary to prevent test specimen degradation or unacceptable reactions (*e.g.,* pyrophoric) that could occur in an air atmosphere. The post-irradiation hot cell facilities would be in close proximity to the VTR. After initial disassembly and examination in the inert atmosphere hot cell, test specimens may be transferred to other post-irradiation examination facilities for additional analysis.

The VTR would generate up to 45 spent nuclear fuel assemblies per year.[8] DOE would use existing or new facilities at the locations identified in the site-specific alternatives for the management of spent driver fuel. DOE will not separate, purify, or recover fissile material from VTR spent nuclear fuel. Spent driver fuel assemblies would be temporarily stored within the reactor vessel for about 1 year. Upon removal from the reactor vessel, surface sodium coolant would be washed off the assembly, and the assembly would be transported in a transfer cask to a new onsite spent fuel pad. After several years (at least 3 years), during which time the radioactive constituents would further decay, the assemblies would be transferred in a cask to a spent nuclear fuel conditioning facility. The sodium that was enclosed within the spent driver fuel pins to enhance heat transfer would be removed using a melt-distill-package process. The spent nuclear fuel would be chopped, and the chopped material consolidated, melted, and vacuum distilled to separate the sodium from the fuel. To meet safeguards requirements, diluent would be added to the remaining spent fuel to reduce the fissile material concentration. The resulting material would be packaged in containers and temporarily stored in casks on the spent fuel pad, pending transfer to an offsite storage or disposal facility. Currently, there is not a

[7] Not all test specimens would require an inert atmosphere during disassembly, analysis, and evaluation. However, separate facilities are not proposed for test specimens that do not require initial post-irradiation examination in an inert atmosphere.

[8] Typically, less than a quarter of the VTR driver fuel assemblies would be replaced at the end of a test cycle. However, there could be atypical conditions when it would be necessary to replace a larger number of assemblies after a test cycle. In such instances, more than 45 assemblies could be removed from the core in a single year.

repository for disposal of spent nuclear fuel, but the conditioned spent driver fuel from the VTR is expected to be compatible with the acceptance criteria for any interim storage facility or permanent repository.

No Action Alternative

Under the No Action Alternative, DOE would not pursue the construction and operation of a VTR. To the extent they are capable and available for testing in the fast-neutron-flux spectrum, DOE would continue to make use of the limited capabilities of existing facilities, both domestic and foreign. Domestic facilities that would likely be used, without modification, would include the INL Advanced Test Reactor and the ORNL High Flux Isotope Reactor. DOE would not construct new or modify any existing post-irradiation examination or spent nuclear fuel conditioning facilities to support VTR operation. Existing post-irradiation examination and spent nuclear fuel conditioning facilities would continue to support operation of the existing reactors. Because there would not be a VTR under the No Action Alternative, there would be no need to produce VTR driver fuel. Therefore, no new VTR driver fuel production capabilities would be pursued. The No Action Alternative would not meet the purpose and need identified for the VTR.

Idaho National Laboratory Versatile Test Reactor Alternative

Under the INL VTR Alternative, DOE would site the VTR adjacent to and east of the Materials and Fuels Complex (MFC) at the INL Site and use existing hot cell and other facilities at the MFC for post-irradiation examination and conditioning spent nuclear fuel (*i.e.*, preparing it for disposal). The VTR complex would occupy about 25 acres. Additional land would be disturbed during the construction of the VTR complex for such items as temporary staging of VTR components, construction equipment, and worker parking. In total, construction activities (anticipated to last 51 months) would result in the disturbance of about 100 acres, inclusive of the 25 acres occupied by the completed VTR complex.

The MFC is the location of the Hot Fuel Examination Facility (HFEF), the Irradiated Materials Characterization Laboratory (IMCL), and the Fuel Conditioning Facility (FCF). The HFEF and IMCL (and other analytical laboratory facilities) would be used for post-irradiation examination and the FCF for spent nuclear fuel conditioning. The existing Perimeter Intrusion Detection and Assessment System (PIDAS) security fencing around the Fuel Manufacturing Facility (FMF) and the Zero Power Physics Reactor (ZPPR) would be extended to encompass most of the VTR facility.

Following irradiation, test and sample articles would be transferred to the HFEF first. The HFEF, a Hazard Category 2 nuclear facility[9], contains two large hot cells. HFEF hot cells provide shielding and containment for remote examination (including destructive and non-destructive testing), processing, and handling of highly radioactive materials.

The IMCL, a Hazard Category 2 nuclear facility, has a modular design that provides flexibility for future examination of nuclear fuel and materials. The IMCL would be used for the study and characterization of radioactive fuels and materials at the micro- and nanoscale to assess irradiation damage processes.

Existing facilities within the MFC would need minor modifications to support fabrication of test articles or to support post-irradiation examination of irradiated test specimens withdrawn from the VTR. These types of activities are ongoing within the MFC.

A new spent fuel pad would be constructed within the VTR site. The spent fuel pad would consist of an approximately 11,000-square foot concrete slab with a 2,500-square foot approach pad. Spent driver fuel would be temporarily stored at the VTR within the reactor

[9] DOE defines hazard categories of nuclear facilities by the potential impacts identified by hazard analysis and has identified radiological limits (quantities of material present in a facility) corresponding to the hazard categories. Hazard Category 1 – Hazard Analysis shows the potential for significant offsite consequences (reactors fall under this category). Hazard Category 2 – Hazard Analysis shows the potential for significant onsite consequences beyond localized consequences. Hazard Category 3 – Hazard Analysis shows the potential for only significant localized consequences. Below (Less Than) Hazard Category 3 applies to a nuclear facility containing radiological materials with a final hazard categorization less than Hazard Category 3 facility thresholds.

vessel, followed by a period of storage on the spent fuel pad. After the fuel cools sufficiently, it would be transferred in a cask to FCF. FCF is a Hazard Category 2 nuclear facility located within a PIDAS. At FCF, the fuel would be conditioned using a melt-distill-package process. The fuel would be chopped, using existing equipment at the FCF. The chopped material would be consolidated, melted, and vacuum distilled to separate the sodium from the fuel. Following addition of a diluent, the mixture would be packaged in containers, placed in storage casks, and temporarily stored on the new spent fuel pad until shipped to an offsite location (an interim storage facility or a permanent repository when either becomes available for VTR fuel).

Under the conceptual design, the existing infrastructure, including utilities and waste management facilities, would be used to support construction and operation of the VTR. The current infrastructure is adequate to support the VTR with minor upgrades and modifications. Radioactive wastes would be shipped off site for treatment and/or disposal.

Oak Ridge National Laboratory Versatile Test Reactor Alternative

Under the ORNL VTR Alternative, the VTR would be sited at ORNL at a site previously considered for other projects, about a mile east of the ORNL main campus. The major structures for the VTR would be the same as those described for the INL VTR Alternative. At ORNL, a new hot cell, a joint post-irradiation examination and spent nuclear fuel conditioning facility, would be constructed adjacent to the VTR. Although there are facilities with hot cells at ORNL that would be used for post-irradiation examination of test materials, none of the available hot cells operates with an inert atmosphere. A new spent fuel pad of the same dimensions as described under INL VTR Alternative would also be constructed.

The new hot cell facility would be approximately 172 feet by 154 feet, four levels, and would rise to about 84 feet above grade. The facility would house four hot cells: two for post-irradiation examinations and two for spent nuclear fuel conditioning. Construction would occur in parallel with the construction of the VTR and be completed in the same 51-month period.

Construction activities would result in disturbance of about 150 acres, with the completed VTR complex, including the hot cell facility, occupying less than 50 acres. The VTR facility, hot cell facility, and spent fuel pad would be located within a single PIDAS.

In addition to the new hot cell facility, existing facilities at ORNL within the Irradiated Fuels Examination Laboratory (Building 3525) and the Irradiated Material Examination and Testing Facility (Building 3025E) would be used to supplement the capabilities of the new post-irradiation examination facility. The Irradiated Fuels Examination Laboratory is a Hazard Category 2 nuclear facility and contains hot cells that are used for examination of a wide variety of fuels. The Irradiated Material Examination and Testing Facility is a Hazard Category 3 nuclear facility and contains hot cells that are used for mechanical testing and examination of highly irradiated structural alloys and ceramics. In addition, the Low Activation Materials Design and Analysis Laboratory would be used for the examination of materials with low radiological content that do not require remote manipulation.

Spent driver fuel would be managed the same as described under the INL VTR Alternative—temporarily stored at the VTR reactor vessel, stored on the spent fuel pad, then conditioned and packaged. Conditioning spent nuclear fuel in preparation for disposal would occur in an inert atmosphere hot cell located in the new hot cell facility adjacent to VTR. Containerized spent nuclear fuel would be placed in storage casks and temporarily stored on the new spent fuel pad until shipped to an offsite location (an interim storage facility or a permanent repository when either becomes available for VTR fuel).

Under the conceptual design, the existing ORNL infrastructure would be extended to the VTR site. The location selected for the VTR is relatively undeveloped and does not have sufficient infrastructure (*e.g.,* roads, utilities, security) to support construction and operation of the VTR. Radioactive waste would be shipped off site for treatment and/or disposal. Waste management capabilities provided by the project (*e.g.,* treatment or packaging of radioactive liquid waste) and facilities within ORNL would be used to support waste management during construction and operation of the VTR.

Reactor Fuel Production Options

The VTR design envisions the use of metallic fuel. The initial VTR core would consist of a uranium/plutonium/zirconium alloy (U/Pu/Zr) fuel that would be 70 percent uranium (uranium enriched to 5 percent uranium-235), 20 percent plutonium, and 10 percent zirconium—a blend identified as U-20Pu-10Zr. VTR driver fuel used in later operations could consist of these elements in different ratios and could use plutonium with uranium of varying enrichments, including depleted uranium or uranium enriched up to 19.75 percent. Annual heavy metal requirements would be approximately 1.8 metric tons of fuel material (between 1.3 metric tons and 1.4 metric tons of uranium and between 0.4 and 0.54 metric tons of plutonium, depending on the ratio of uranium to plutonium).[10] Feedstock for this fuel could be acquired from several existing sources.

DOE's plan for providing uranium for fabricating VTR driver fuel is to acquire metallic uranium from a domestic commercial supplier. If another source of uranium were to be selected, DOE would conduct a review to determine if additional NEPA analysis would be needed. Other possible sources are DOE managed inventories of excess uranium acquired from many sources, including U.S. defense programs and the former DOE uranium enrichment enterprise. Some of the uranium is enriched and could be down-blended for use in VTR driver fuel.

Existing sources of U.S. excess plutonium[11] managed by DOE and the National Nuclear Security Administration (NNSA) would be sufficient to meet the needs of the VTR project.

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[10] The cited quantities are those for finished fuel as it is placed in the reactor and correspond to fuel that is from 20 to 27 percent plutonium. Accounting for additional material that ends up in the waste during the reactor fuel production process, up to 34 metric tons of plutonium could be needed for startup and 60 years of VTR operation.

[11] Excess plutonium includes pit and non-pit plutonium that is no longer needed for U.S. national security purposes.

Potential DOE/NNSA plutonium materials include surplus pit[12] plutonium (i.e., metal), other plutonium metal, oxide, and plutonium from other sources. If the U.S. sources cannot be made available for the VTR project or to supplement the domestic supply, DOE has identified potential sources of plutonium in Europe.

VTR driver fuel production evaluated in the EIS involves two steps or phases: feedstock preparation and fuel fabrication. Depending on the impurities of the source material, a polishing process, or a combination of processes, would be required. These processes would be performed in a series of gloveboxes[13] to limit worker radiological exposure.

Three potential feedstock preparation processes are under consideration: an aqueous capability, a pyrochemical capability, and a combination of the two. In the aqueous process, the plutonium feed (containing impurities) is dissolved in a nitric acid solution and through a series of extraction and precipitation steps, a polished plutonium oxide is produced. The oxide is converted to a metal in a direct oxide reduction process. In one form of the pyrochemical process (molten salt extraction), the metallic plutonium feed is combined with a salt and the mixture raised to the melting point. Impurities (*e.g*., americium) react with the salt, and the polished plutonium is collected at the bottom of the reaction crucible. If the pyrochemical process were selected, a direct oxide reduction process would also be required to convert plutonium dioxide feeds to plutonium metal. If a combination of the two processes were to be selected, a smaller aqueous line to prepare this fuel could be incorporated into the pyrochemical process.

Fuel fabrication would use an injection casting process to combine and convert the metallic ingots into fuel slugs. In a glovebox, a casting furnace would be used to melt and blend

[12] A pit is the central core of a primary assembly in a nuclear weapon and is typically composed of plutonium metal (mostly plutonium-239), enriched uranium, or both, and other materials.
[13] Gloveboxes are sealed enclosures with gloves that allow an operator to manipulate materials and perform other tasks while keeping the enclosed material contained. In some cases, remote manipulators may be installed in place of gloves. The gloves, glass, and siding material of the glovebox are designed to protect workers from radiation contamination and exposure.

the three fuel components: uranium, plutonium, and zirconium. The molten alloy then would be injected into quartz fuel slug molds. After cooling, the molds would be broken, and the fuel slugs retrieved. Fuel pins would be created, using stainless steel tubes (cladding) into which a slug of solid sodium would be inserted, followed by the alloy fuel slugs. The fuel slugs and sodium would occupy about half of the volume of the fuel pin with the remainder containing argon gas at near atmospheric pressure. The ends of the tubes would be closed with top and bottom end plugs. These activities would take place in gloveboxes with inert atmospheres. Once fully assembled, the fuel pins would be heated sufficiently to melt the sodium and create the sodium bond with the fuel. The sodium-bonded fuel would fill about half the length of the fuel pin. Fuel pins would be assembled into a fuel assembly with each fuel assembly containing 217 fuel pins. Sodium bonding and producing the fuel assemblies would be performed in an open environment. No gloveboxes would be required.

Operationally, the feedstock preparation and fuel fabrication capabilities would need to generate about 66 fuel assemblies for the initial VTR core. Thereafter, the capabilities would need to produce up to 45 fuel assemblies per year.

The EIS evaluates the INL Site and SRS as potential locations for performing the activities necessary for driver fuel production for the VTR. Independently, DOE would establish and operate all or part of the fuel fabrication capability at either site. DOE is not making a decision regarding driver fuel production in this ROD.

Potential Environmental Impacts

Implementation of either the INL VTR Alternative or the ORNL VTR Alternative would generally have small environmental consequences. Overall, the environmental consequences would be smaller at the INL Site for several reasons. The total area that would be temporarily disturbed and the area that would be permanently occupied by the VTR complex would be smaller at the INL Site because of the need to build a new hot cell facility if the VTR were located at ORNL. Unlike the INL Site, the ORNL location abuts wetlands that would have to be avoided or managed in accordance with Clean Water Act and State of Tennessee regulations. The removal of trees at the ORNL location would also result in the loss of roosting habitat for sensitive bat species. The potential radiological impacts would be small at both locations but would be smaller at the INL Site because the VTR would be further from the site boundary and the population density is lower near the INL Site than near ORNL.

Implementation of the reactor fuel production options at either the INL Site or SRS would generally have small environmental consequences. At both locations, existing facilities would be modified or adapted to provide capabilities for feedstock preparation and fuel fabrication. Disturbance of a minimal area (up to 3 acres) would occur at SRS. Because there is existing staff at the INL Fuel Manufacturing Facility, fewer new employees would need to be hired for fuel fabrication at the INL Site. Potential radiological impacts would be small at both sites, but due to differences in population density and distribution, potential impacts would be somewhat smaller at the INL Site.

Environmentally Preferable Alternative

The No Action Alternative would be the Environmentally Preferable Alternative. Under the No Action Alternative, DOE would not pursue the construction and operation of a VTR. To the extent they are capable and available for testing in the fast-neutron-flux spectrum, DOE would continue to make use of the limited capabilities of existing facilities, both domestic and foreign. Construction and operation of a VTR and associated support facilities would not occur, resulting in less impacts than under the Action Alternatives. However, the No Action Alternative would not meet the purpose and need for a domestic fast-neutron-spectrum testing capability.

Comments on Final VTR EIS

DOE made more than 1,850 notifications of the completion and availability of the Final VTR EIS to Congressional members and committees; states, including Idaho, Tennessee, and

South Carolina; Tribal governments and organizations; local governments; other Federal agencies; non-governmental organizations; and individuals. Following issuance of the Final VTR EIS, DOE received four letters and/or emails. DOE considered the comments received following issuance of the Final VTR EIS and finds that they do not present "significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" within the meaning of 40 CFR 1502.9(c) and 10 CFR 1021.314(a), and therefore do not require preparation of a supplement analysis or a supplemental EIS.

DOE addressed two of the emails received – a press inquiry and a process question – directly with the people who submitted them.

A third email/letter received included multiple comments on a variety of topics. One related to the author's Freedom of Information Act request and has no bearing on or relevance to the environmental impacts evaluated in the EIS. It also contained another question of whether the Office of Nuclear Energy would have the ability and funds to establish a VTR fuel fabrication project at SRS. As appropriate, the VTR EIS evaluated the potential environmental impacts of a fuel fabrication capability at SRS; the administrative and funding items are factors DOE would consider when it makes a decision regarding fuel fabrication.

Other comments posed questions about the plutonium for VTR driver fuel fabrication, a nonproliferation assessment, and management of transuranic waste resulting from fuel fabrication activities. Similar topics were raised in comments on the Draft VTR EIS. DOE responded to these comment topics in Volume 3 of the Final VTR EIS and revised the EIS as necessary to fully address these topics commensurate with the stage of project development.

This third letter/email also incorrectly stated that the VTR had been "terminated" and the "EIS [was] improperly issued after termination." Additionally, it requested "that no Record of Decision (ROD) be issued on the project." While it is correct that Congress did not appropriate funds for VTR in fiscal year 2022, the Energy Act of 2020, included in the Consolidated

Appropriations Act (Pub. L. 116-68), authorized full funding for the VTR project. DOE is following Council on Environmental Quality guidance to integrate NEPA into the planning process early to ensure planning and decisions reflect environmental values, to avoid delays, and to head off potential conflicts. By issuing the Final VTR EIS and ROD, DOE is taking important steps, consistent with the Energy Act of 2020, by deciding whether and where to construct the VTR. In accordance with its authorization in the Energy Act of 2020, DOE will work with Congress to obtain the funding needed to execute this important project.

The fourth letter/email recommended that DOE clarify management approaches for spent driver fuel beyond January 1, 2035. As indicated in the response to comments received from the State of Idaho and as revised in the Final VTR EIS, prior to issuing this ROD, DOE committed to exploring potential approaches with the State of Idaho to clarify and, as appropriate, address potential issues concerning management of VTR spent nuclear fuel beyond January 1, 2035; those discussions are ongoing. Spent driver fuel from the VTR, regardless of whether it was generated before or after January 1, 2035, would be stored within the VTR reactor vessel until decay heat generation is reduced to a level that would allow fuel transfer and storage of the fuel assemblies with passive cooling. After allowing time for additional radioactive decay, the spent fuel would be transferred to a spent nuclear fuel conditioning facility. At the facility, the spent fuel would be chopped, melted, and vacuum distilled to remove the sodium, after which the fuel would be diluted and placed in canisters ready for future disposal. The canisters would be placed in dry storage casks and stored on site in compliance with all regulatory requirements and agreements. This VTR spent nuclear fuel would be managed at the site until it is transported off site to an interim storage facility or a permanent repository.

Decision

DOE has decided to implement its Preferred Alternative as described in the Final VTR EIS. DOE's Preferred Alternative is to construct and operate a VTR at INL, and to establish, through modification and construction, co-located facilities for post-irradiation examination of test products and for management of spent VTR driver fuel at INL.

DOE has not decided whether to establish VTR driver fuel production capabilities for feedstock preparation and fuel fabrication at the INL Site, SRS, or a combination of the two sites. Once a preferred alternative/option for VTR driver fuel production is identified, DOE will announce its preference in an FR notice. DOE would publish a record of decision no sooner than 30 days after its announcement of a preferred alternative/option for VTR driver fuel production.

Basis for the Decision

The Final VTR EIS provided the DOE decision-maker with important information regarding potential environmental impacts of alternatives and options for satisfying the purpose and need. In addition to environmental information, DOE considered other factors including public comments, statutory responsibilities, strategic objectives, technology needs, safeguards and security, cost, and schedule, when making its decision.

Mitigation Measures

No potential adverse impacts were identified that would require additional mitigation measures beyond those required by regulation and agreements or achieved through design features or best management practices. However, the INL VTR Alternative has the potential to affect one or more resource areas. If during implementation, mitigation measures above and beyond those required by regulations are identified to reduce impacts, they would be developed, documented, and executed.

Signing Authority

This document of the Department of Energy was signed on July 22, 2022, by Robert Boston, Manager, Idaho Operations Office, Office of Nuclear Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with the requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. The administrative process in no way alters the legal effect of this document upon publication in the *Federal Register*.

Signed in Washington, DC, on July 29, 2022

Treena V. Garrett,
Federal Register Liaison Officer,
U.S. Department of Energy.

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